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HYBRID ENERGY STORAGE SYSTEM IN PLUG-IN HYBRID ELECTRIC VEHICLE USING PARTICLE SWARM OPTIMIZATION

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Abstract:

Plug-in Hybrid Electric Vehicles (PHEVs) offer a compelling solution for reducing dependence on fossil fuels and mitigating greenhouse gas emissions. However, achieving optimal performance hinges on effectively managing the on-board hybrid energy storage system (HESS), which typically combines a battery and potentially a supercapacitor. It shows the energy loss minimization of a hybrid energy storage system used in an electric vehicle, composed by a battery and a supercapacitor. This research suggests that the best way to create a plug-in hybrid electric vehicle (PHEV) with high energy economy (HESS) is to use particle swarm optimization (PSO) to determine the engine, motor, battery, and supercapacitor (SC) sizes simultaneously. PSO is a technique used to determine the optimal size of the power supply and energy system that can meet the load requirements of a driving cycle. A statistical study was conducted to evaluate the algorithms' performance for varying swarm sizes after they were evaluated for minimizing energy loss in the driving cycle. PSO is a technique used to determine the optimal size of the power supply and energy system that can meet the load requirements of a driving cycle. A statistical study was conducted to evaluate the algorithms' performance for varying swarm sizes after they were evaluated for minimizing energy loss in the driving cycle.

Keywords: plug-in hybrid electric vehicle (PHEV), hybrid energy storage system (HESS), particle swarm optimization (PSO), All electric range (AER), size optimization.

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I. INTRODUCTION

The plug-in hybrid electric vehicle (PHEV) has a long driving range and a large capacity power battery pack that allows it to refuel from the grid. It has outstanding fuel efficiency and can, however, recover more brake energy. Additionally, PHEVs can be connected to the grid using vehicle-to-grid technology, which will make it easier to adopt energy-saving and emission-reduction strategies and guarantee a more flexible use of car batteries. The PHEV is growing in popularity as a result. The vehicle's power requirements necessitate frequent charging and discharging of the battery, which will unavoidably hasten battery ageing. A PHEV's braking energy can be stored in the battery as well as the SC when the HESS is used. While the energy in the battery can be used to smoothly supply the vehicle's electrical needs, the energy in the SC can be used to accelerate the car. The high-power density and long cycle life of the hybrid energy storage system (HES) when compared to the battery energy storage system (BESS) would significantly enhance the vehicle's overall performance. Urban traffic cars are increasingly using HESSs for regenerative braking energy recovery, as it is a more cost-effective solution.

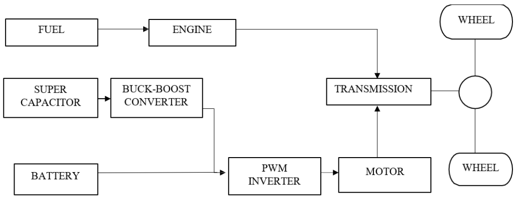
The design of a smaller size and a longer service life are the two main problems facing the application of HESSs. In order to address these issues, the PSO algorithm must simultaneously optimise the energy management strategy (EMS) and the size of the

HESS in order to calculate the engine, motor, battery, and supercapacitor sizes in a plug-in hybrid electric vehicle (PHEV) with HESS.

II.LITERATURE SURVEY

In proposal ,the technical and business management of a virtual energy hub that consists of an electric transportation system, a bus electric charging station powered by batteries, and an electric vehicle parking lot that is integrated with a combined battery storage system. Based on the best predetermined set points from the grid agent, the VEH agent can act independently during real-time operation to handle the power system's volatility and efficiently manage the grid's requirements.[2] Electric automobiles are better for the environment than internal combustion engines. Fuel is more expensive than electricity. Maintenance requirements for electric vehicles are lower than those of internal combustion engines. The lack of charging stations, higher cost of electric cars compared to ordinary cars, limited range after charging, and fear of lengthy drives among consumers are some of the issues with electric cars. One thing that keeps people from buying electric cars is their expensive price.[3] The many approaches to PHEV smart charging strategy, MG formulation, energy cost, security constraints, and generation and consumption balance were described. Additionally, an explanation of the q-MKH-based optimisation method using 2m-PEM as the stochastic framework was provided.[4] based on the Pontryagin's Minimum Principle algorithm. Following the identification of several consistent trends in the numerical PMP data, the piecewise linear approximation approach was used, indicating the engine fuel rate turning point for the Hamiltonian optimisation.[5] In order to estimate the short-term vehicle velocity and determine the future power consumption based on the prediction results, they first use a time-series forecasting method. To increase system robustness, prediction error is taken into account when formulating MPC. Based on driving profile testing, simulation findings show that, in comparison to the current approaches.

III.PROPOSED SYSTEM



Fuel is used to provide the engine, which in turn powers the wheels through the gearbox in modern cars with both conventional internal combustion engine and electric propulsion systems. Electrical power is managed and supplied by energy storage devices such as batteries and supercapacitors, with the former providing high power for brief bursts and the latter guaranteeing a steady supply of energy. The PWM inverter and buck-boost converter are examples of power conversion equipment that guarantee energy storage devices and electric motor compatibility. This component integration leads to better overall efficiency, better vehicle performance, and effective energy management.

Step 1: Set the swarm and vehicle model to initial values. The swarm then has to be inside the optimisationinterval.

Step 2: Give each population value a unique simulation assignment. Then, get the vehicle performance and determine whether the constraint condition is met. If not, remove the individual value and output the total cost. You can also update the p best, g best, and the position and speed of each particle.

Step 3: Check to see if the end of condition is satisfied; if not, go back to Step 2 and carry out iterative optimisation, figuring out each particle's position and speed in a fresh population and coming up with the best possible optimisation outcome. Both the number of PSO populations and iterations are twenty. To imitate the AER constraint, the motor operates the vehicle independently. The battery is set up with a minimum SOC of 0.2 and a beginning SOC of 0.9. The intended driving cycle is the Driving Schedule (UDDS), and the different AERs are 40, 60, and 80 km. In the simulation, if the incremental trajectory exceeds the specified speed of 3.2 km/h, the AER constraint is not met.

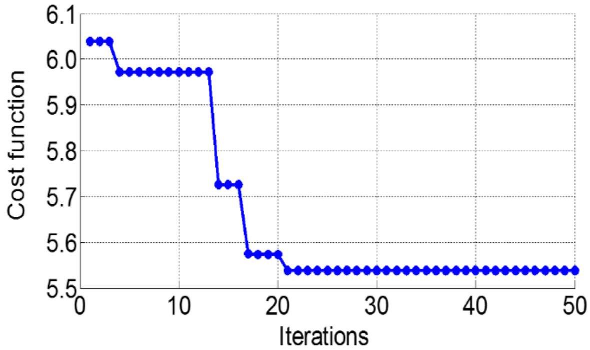


Fig 2 The iterative process of the PSO approach.

In order to reduce the powertrain system's energy consumption, the energy management strategy is in charge of operating mode switching and ideal power distribution. As previously mentioned, two popular rule-based strategies for plug-in hybrid electric vehicles (PHEVs) are the blended strategy and the CD-CS strategy, which alternates between using the engine and the battery to meet the vehicle's power needs throughout the entire range. The CD-CS strategy involves operating the vehicle entirely in electric mode until the battery SoC falls below a predefined threshold, at which point it switches to the CS mode. The PSO algorithm is based on a novel rule-based approach that is created by combining the CD-CS and blend strategies. For the PHEV's operating mechanism, three modes are defined. The first mode is known as the CD-E (charge depleting electric) mode. The car will activate the second mode, charge depleting hybrid (CD-H) mode, if the battery SoC is somewhat less than 0.4. If the battery SoC is more than a relative low threshold, the vehicle will operate in the CD-E mode .In this mode, the battery pack and EGS work together as a hybrid energy supply system, dividing the power demand between them in accordance with the optimisation algorithm. As long as the battery pack remains one of the primary power supply components, the battery SoC will keep getting smaller. The third option, known as charge-sustaining (CS) mode, in which the EGS serves as the primary power supply and the battery only stores kinetic energy during braking, will be activated when the SoC reaches a lower threshold.

The PSO method is utilised to determine the best control among all the solutions, ρ*= [PX* PY* P1* P2*]. For a certain driving that spans the time interval [t, tf], the PHEV optimisation goal is as follows:

$$J_{AB}=\int \dot{m}_{f}(u(\rho),x(t),t)\,dt \qquad (1)$$

Based on the available operation modes, the entire driving route of PHEVs can be divided into three periods, allowing the optimisation goal function shown in Equation to be satisfied. This ensures that the driving time of the provided speed profile is long enough to achieve the minimum capacity of the battery pack.

$$J_{AB}=J_{CD\text{-}E}+J_{CD\text{-}H}+J_{CS} \qquad (2)$$

$$=\int \dot{m}_{f}(u(\rho),x(t1),t)dt+\int \dot{m}\,f(u(\rho),x(t1),t)dt+\int \dot{m}_{f}(u(\rho),x(t1),t)dt$$

While the EGS takes over in CS mode to maintain the battery SoC level, electricity predominates in CD-E mode to enable clean and affordable travel. The optimisation technique fails in these two scenarios because the control rules are extremely explicit and completely fixed. The best course of action can only be implemented in the CS-H mode, as fuel and electricity combine to meet the power need in this mode. The global optimal issue can be reformulated as the problem of minimising the energy cost in CD-H mode, since there is a degree of freedom permitting the power split between the battery pack and EGS. Equation can be used to rewrite the optimisation goal. Here, the total of fuel and electricity use is used to define the energy cost:

$$J_{CD\text{-}H} = \int \dot{m}\,f(u(\rho),\ x(t1),\ t)\ dt= \int (P_{e}(t)+\ \kappa 4/\kappa 5\ P_{batt}(t))\ dt \qquad (3)$$

Therefore, the best way to characterise the optimisation problem is as follows: determine the optimal control policy u* to minimise JCD-H.

$$J_{CD\text{-}H}\,(u(\rho*))\ \le\ J_{CD\text{-}H}\,(u(\rho))\ \ \forall u\in U$$

To ensure that the optimal outcome is one of the workable options, a few constraints must be followed while the optimisation process is running. The limitations for threshold values are displayed in Equation in accordance with the threshold design guidelines.

$$0 \le P_{X}\le P_{opt}\le P_{Y}\le P_{1}\le P_{e,\max} \qquad (4)$$

$$P_{X}\le P_{2}\le P_{e,\max} \qquad (5)$$

IV RESULTS AND DISSCUSSION

This method's effectiveness is assessed by simulating the strategy using a forward simulation model in the MATLAB/Simulink program. Thus, the engine power, battery power, and battery SoC simulation results with four cycles (51.5 km) as speed. The battery's starting state of charge (SoC) is set to 0.4 because the primary purpose of the simulation is to verify the optimisation procedure used on CD-H mode. As the driving cycle comes to a close, SoC falls to roughly 0.3. The power split found by the PSO algorithm appears to be a compromise between the engine dominant blended approach and the electricity dominant blended strategy, as both the battery and the engine output power are evident throughout nearly the whole driving cycle. The chosen hybrid approach divides the power needed for the engine and batteries during the driving distance. The EGS provides electric power according to the optimal curve when the power demand is less than its maximum power; if the power demand is more than the EGS's power capacity, the battery will provide additional power to meet the need.

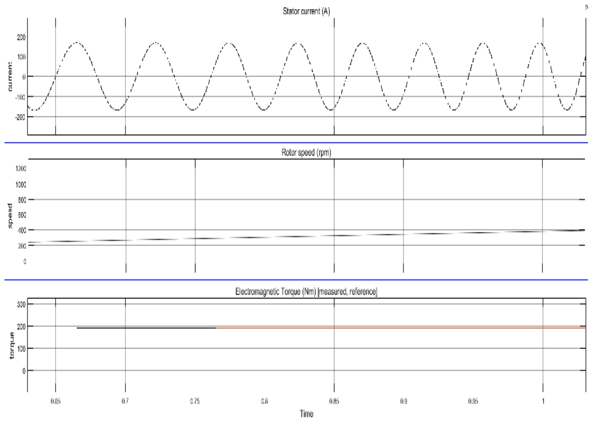


Fig 3 Output waveform of PSM motor

The figure 3 demonstrates how the electromagnetic torque, rotor speed, and stator current all change over time. While the rotor speed and electromagnetic torque seem more erratic, the stator current appears to be sinusoidal.

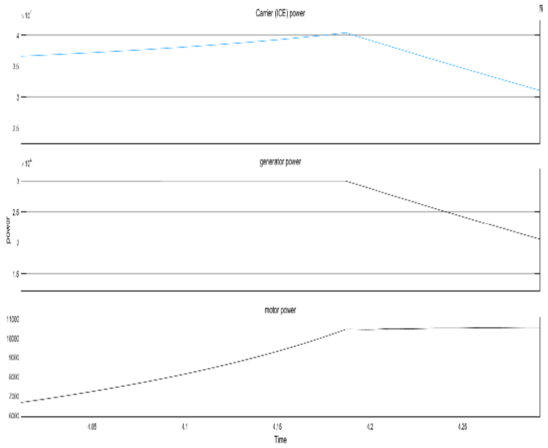


Fig 4 Output waveform of electric vehicle powertrain

The image illustrates how the carrier (ICE) power consumption increases gradually over approximately 0.15 seconds to reach around 10 watts (W) from a starting point of about 3 watts (W). After that, it remains at 10 watts (W) for the remainder of the duration. Based on the generator power graph, the power consumption starts at approximately 1.5 watts (W) and rises to approximately 2.5 watts (W) in about 0.1 seconds. After that, for the remainder of the time depicted in the image, it varies somewhat around 2.5 watts (W). The motor power graph then demonstrates that, during the course of around 0.1 seconds, the power usage drops from approximately 6000 watts (W) to approximately 7000 watts (W). After that, it keeps becoming smaller.

V CONCLUSION

The sizes of the parts of a PHEV with a HESS were ascertained in this paper using a PSO technique. The engine, motor, battery, and supercapacitor specifications were chosen as optimisation factors in order to minimise the drivetrain cost while maintaining the necessary driving performance. According to the optimisation results, a HESS with a Ni-MH battery can have a drivetrain cost that is up to 12.21% less than a HESS with a Li-ion battery. In contrast to the theoretical study results, PSO optimises a drivetrain cost reduction of 8.79%. In comparison to an energy storage system without supercapacitors, the supercapacitor can extend the battery life, resulting in a 12.34% reduction in drivetrain costs. However, the engine and motor parameters increased slightly and the initial cost of the supercapacitor was higher. Select three distinct drive cycles to optimise in order to examine how a drive cycle affects component sizing. he findings of the simulation demonstrate that when cycle aggressiveness increases, the parameters of the engine, motor, battery, and supercapacitor rise along with the vehicle's mass and drivetrain cost. To maximise the efficiency of plug-in hybrid electric vehicles (PHEVs), a sensible energy management plan is required.

ACKNOWLEDGEMENT

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